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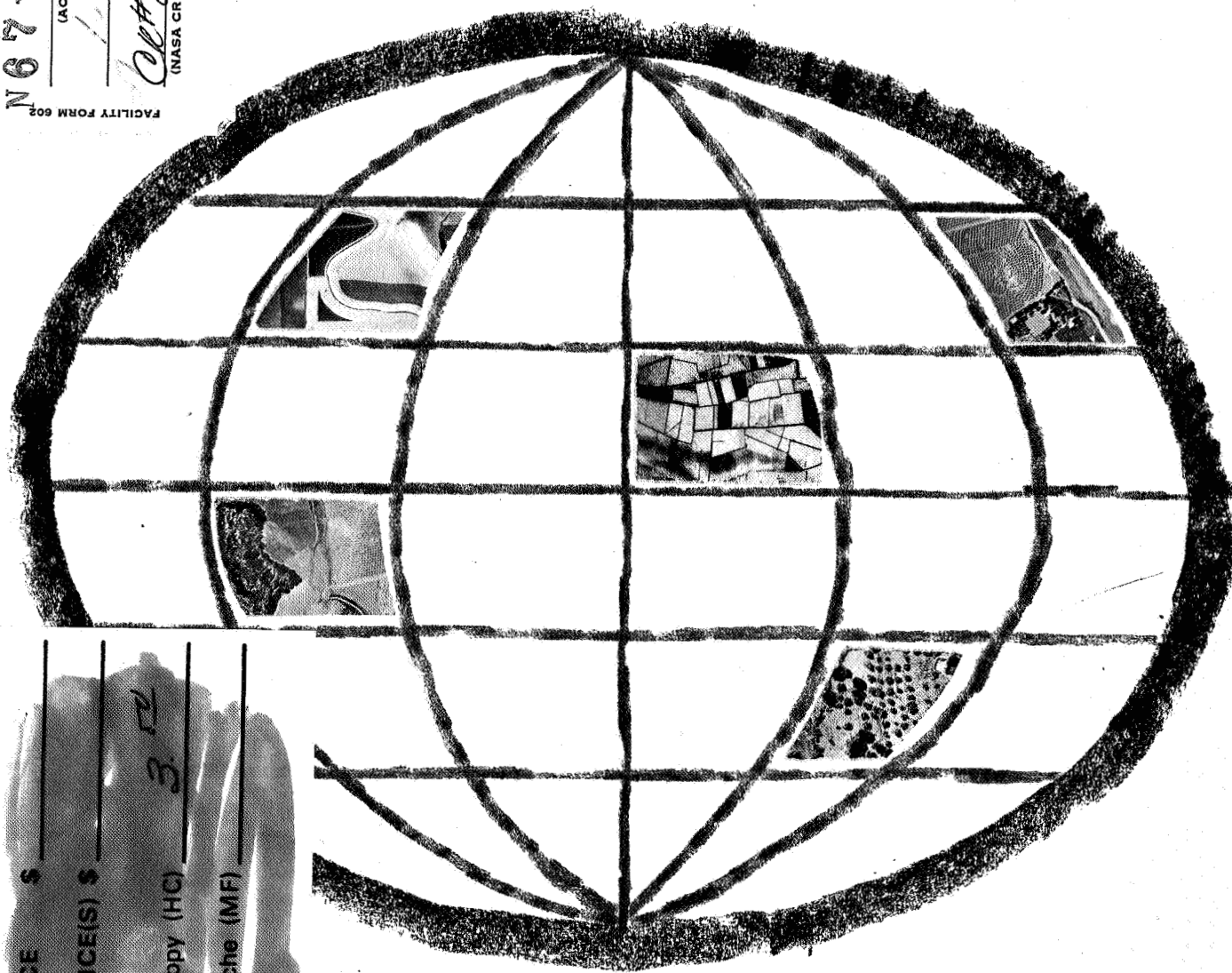
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WORLDWIDE USE of AIRPHOTOS in AGRICULTURE

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PREFACE

This bulletin was originally prepared for the National Aeronautics and Space Administration as part of an overall study to appraise potential benefits from obtaining land-use and other agricultural data from earth-orbiting satellites. Its purpose here is to present an overview of the current use of airphotos in a sample of countries-selected as being representative. An attempt was made to include countries at varying stages of development from every continent except Antarctica.

Some omissions of important applications of airphotos undoubtedly occur since not all applications have been documented. Moreover, with increasing usage in the past few years, particularly in the less developed countries, the available information may not be up to date. Even so, the handbook presents a reasonably accurate picture of current uses of airphotos in agriculture both in the United States and abroad.

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Washington, D. C.

September 1967

SUMMARY

Use of airphotos in agriculture is increasing throughout the world, and **will** likely become more intensive in the future. This **is** especially true for the larger countries where problems of obtaining data over wide areas are acute and for the less developed areas where **time is** a critical factor in getting agricultural development underway. Many countries are just beginning to use airphotos as the most efficient means for carrying out inventory and planning studies essential for orderly development. In countries where U. N. Special Fund projects are in operation, airphotos are being used by trained scientists to conduct surveys and to train counterpart local personnel. It is anticipated that countries using airphotos as the base for survey, interpretation, and program implementation will continue to do **so**. Several less developed countries have expressed a need for regional training centers to instruct people in the use **of** airphotos in the setting in which they **will** work.

In the more developed countries where more data are available, the **major** use of airphotos will probably be to provide up-to-date **information** on land-use and other changes affecting agriculture. Finally, it is anticipated that continued **improvement** in airphoto quality and resolution, along with development of other remote sensing devices, will be applied in agriculture to provide more precise data, particularly in specific crop identification and to fill the ever-present needs for up-to-date **information**.

WORLDWIDE USE OF AIRPHOTOS IN AGRICULTURE

by

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INTRODUCTION

The use of aerial photographs in agriculture to provide data on agricultural production and to aid in inventory, planning, and development has increased throughout the world, particularly in recent years. In many countries, especially in the less developed areas, use of airphotos is just beginning and will likely increase as these airphotos form the base for planning and implementing agricultural development.

In general, two basic types of data are needed to plan, oversee, and sustain efficient agriculture: compiled statistical information and maps showing distribution, pattern, and geographic location of land use, soils, and other data. Compiled data typified by the agricultural census are obtained by complete field surveys, surveys of samples, mail questionnaires, or by personal interviews. Agricultural data displayed on maps (soil maps, for example) are generally based on detailed field work. In some situations, it is necessary for the soil scientist to make the base map while determining the soil classification, although within recent years airphotos have been used to accelerate field surveys or to aid in reducing the amount of field work.

FACTORS INFLUENCING THE USE OF AIRPHOTOS

In the years between World Wars I and II, increasing needs for data on agriculture and improvements in the technique of aerial photography prompted investigation of the possible use of airphotos to save time and money, and to make optimum use of trained people in obtaining data. During this period, the inception of crop control, soil conservation, resettlement, and development programs created a need for up-to-date base maps on a fairly large scale. Concurrently, there arose a need for more rapid mapping of land use, soils, extent of soil erosion, and other basic data for use in planning control measures, particularly in soil conservation and watershed management projects. The Soil Conservation Service, U. S. Department of Agriculture, has recently published an excellent account of the evolution of airphotos and the development of the Department's program for procuring airphoto coverage (24). ^{1/} Following World War II and based on experience in stereoscopic interpretation of airphotos in military intelligence, airphoto interpretation was applied to problems of data collection in agriculture in many parts of the world.

^{1/} Underscored numbers in parentheses refer to References, p. 21.

Use of airphotos" in agriculture varies widely, ranging from very limited in ~~some~~ countries to extensive in others. In general, the greatest use ~~has~~ been made in the larger countries where information is needed for large areas as quickly ~~as~~ possible and in the less developed areas for getting agricultural development underway. In many countries, airphotos also enable optimum use ~~of~~ scarce professional personnel. In the more developed areas, airphoto interpretation provides a very economical means of getting up-to-date information on land-use changes in agriculture due to urbanization, reversion of less favorable areas to forest, clearing and draining forest land, and installation of irrigation systems in dry areas. (5)

An unusual illustration of the need for airphotos has occurred in New Guinea where airphotos taken in recent years have already become obsolete:

Vertical airphotos at a scale of 1:50,000 in the southern half of the area and 1:40,000 in the north taken on flights by Adastral Airways in 1956 and 1957, gave complete coverage save for a very ~~small~~ area near Kubuna. These were supplemented by airphotos of the Kubuna One-Mile Sheet taken in 1961. The age of the photos was a source of inconvenience at many points in the survey (1962), as tracks, garden patterns, and plantation limits have changed in many areas and notably the Angabunga River has undergone a major change of course with important consequences to land-system patterns (2, No. 14).

Until recent times, wider use of airphotos in agriculture was hampered by lack of knowledge of their capability for providing useful data, seemingly high costs of aerial photography, and lack of personnel trained in airphoto analysis techniques. However, successful application of airphoto interpretation in agriculture and agricultural development planning in several countries has demonstrated its utility. While few attempts have been made to compute a direct monetary value, ~~some~~ benefits have been demonstrated: (1) reduction in time needed for completion of projects, (2) savings in time and cost for field surveys, (3) capability for coverage of large and inaccessible areas, and (4) more efficient use of limited numbers of trained professional personnel. With increasing recognition ~~of~~ the above benefits throughout the world, ~~many~~ countries are already using airphotos in connection with agriculture or are acquiring the necessary photography, training personnel, and planning for efficient use of airphotos.

MAJOR APPLICATIONS OF USE OF AIRPHOTOS

Airphotos in agriculture are generally used: (1) to provide a base for field surveys, (2) to supply information by stereo interpretation ~~of~~ airphotos, and (3) to serve as a base for planning, administering, and recording agricultural programs .

Base for Field Survey

Use of airphotos as a detailed map for recording agricultural data, one of the earliest applications, is continuing to spread around the world in soil, land-use, and vegetation mapping. Data mapped in the field can be measured and reported as compiled information. The annotated photograph can be reproduced as a map, or colored line maps can be made from the photograph. In a recent soil survey report, the soil information is shown on a controlled airphoto mosaic reproduced as the final map (fig. 1).

Airphoto Interpretation

Stereoscopic study of airphotos to obtain agricultural data was very limited until after World War II, but has increased steadily since that time, particularly in Australia, Canada, the Netherlands, the United Kingdom, and the United States.

Airphoto interpretation can provide acreage data by measurement with planimeter or grid, or the annotated photograph can be reproduced for use as a map. In addition, line maps can be prepared by making overlays or transferring data from the annotated airphoto. Figures 2-5 illustrate the use of airphoto interpretation to provide information in Australia, Chile, the Republic of Dahomey, and the United States.

Base for Agricultural Programs

The use of airphotos as a base for planning, administering, and recording agricultural programs is increasing throughout the world. Airphotos are being used to show property lines, program plans, progress, etc., in crop control, soil conservation, irrigation, reclamation, land reform, and colonization projects. Airphotos are a prerequisite in most of the inventory and development projects being carried out under the U. N. Special Fund and is scheduled for delivery before operations can begin. Figure 6 illustrates the use of airphotos in the operation of agricultural programs in the United States.

SPECIFIC USES OF AIRPHOTOS IN AGRICULTURE

Throughout the world airphotos have been applied in a substantial number of subject matter fields. These include the following:

Soil classification	Watershed and hydrologic studies
Land-use capability	Recreation site evaluation
Land-use classification	Wild life habitat studies
Land-use changes	Wildlife inventory and management
Natural vegetation	Soil conservation programs
Livestock and range surveys	Irrigation development
Crop identification	Agricultural development projects
Crop disease detection	Agrarian reform programs
Flood control survey	Crop acreage control programs
Water development	



(68) | (Joins sheet 69)

R. 39 W.

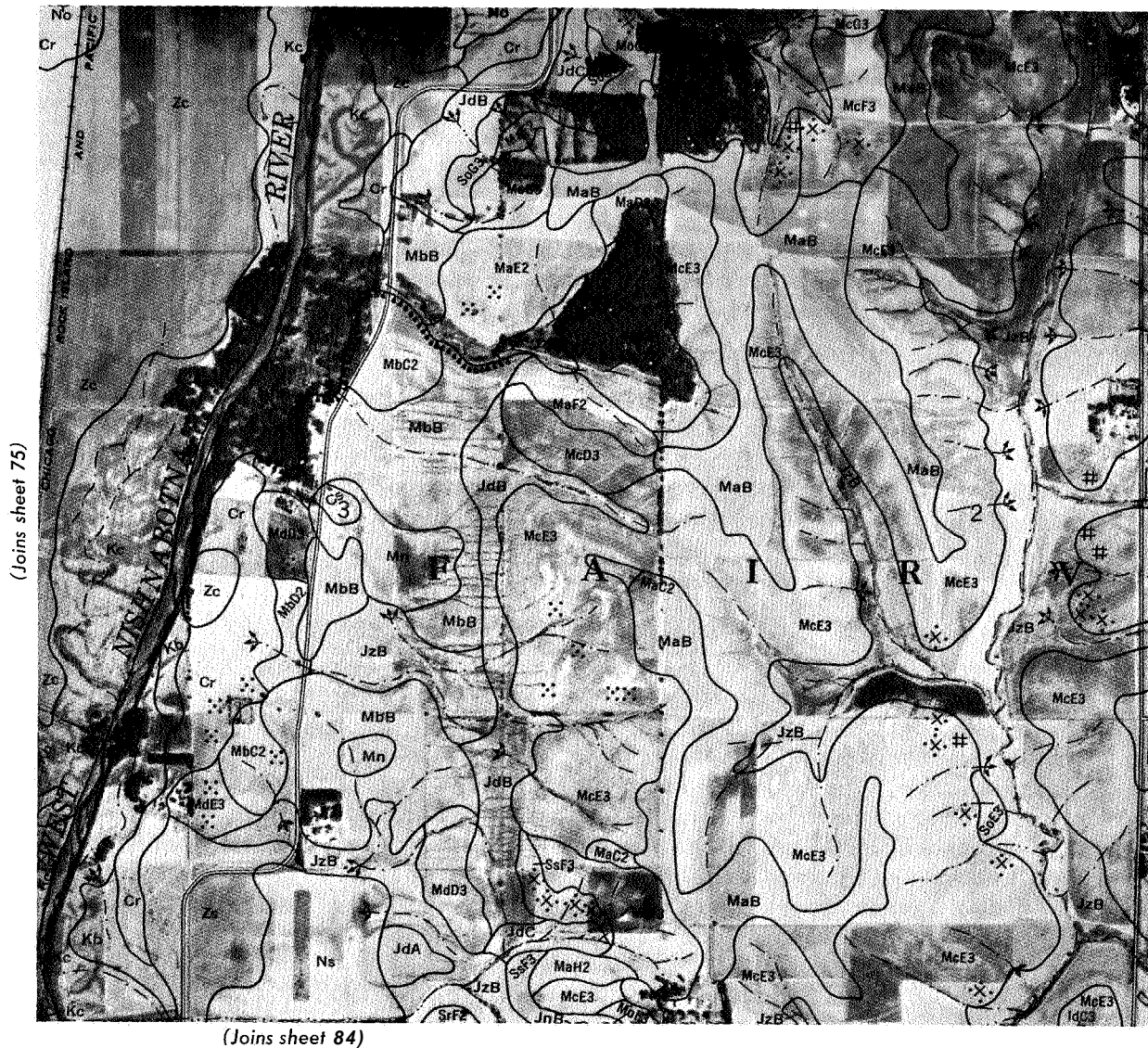


Figure 1. This photograph shows a portion of a recently published county soil survey in the United States, illustrating the use of airphotos as a base for field mapping and use of the annotated mosaic as a final map. The soil name, the amount of slope and the degree of erosion are shown by symbol. (Soil Conservation Service, U. S. Department of Agriculture)

0 $\frac{1}{2}$ Mile Scale 1:15 840 0

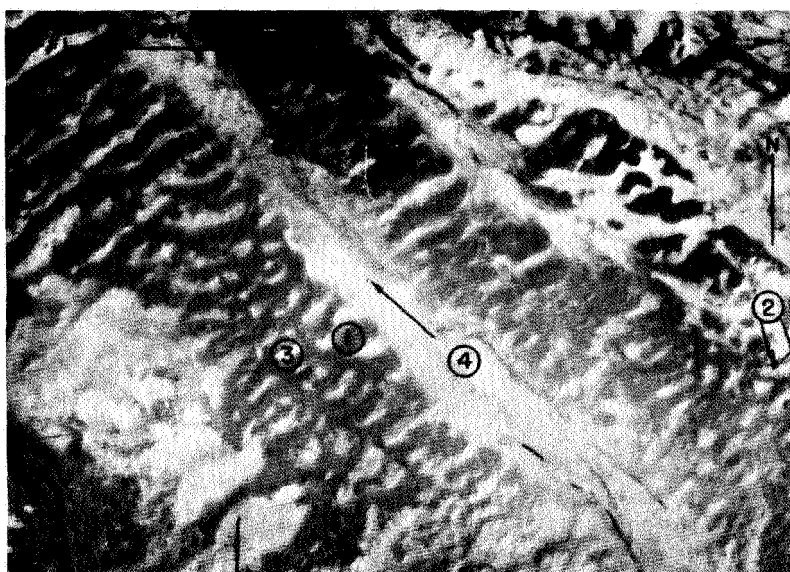
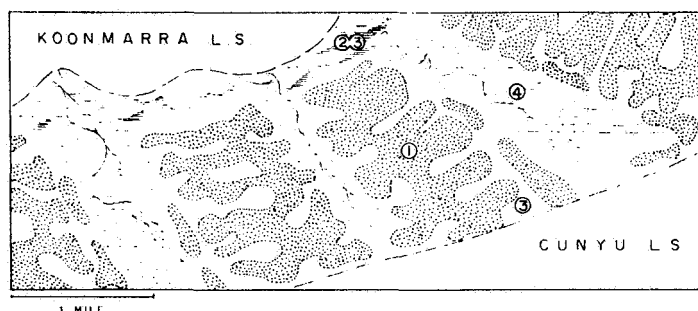


Fig. 2.—The method of survey is based on the concept that each land system is expressed on air photographs by a distinctive pattern. This aerial view of Bebele land system (No. 41) shows alternating low sandy banks (dark grey) and alluvial flats (light grey) traversed by lightly channelled flood-plains, with minor mulga groves (black). These 4 elements form distinct land units as numbered. In all, 48 land systems have been mapped and described in the survey area.



Unit	Approx Area (sq. miles)	Land Form	Soil and Soil Association	Vegetation
1	700	Wnnderrie hanks: up to $\frac{1}{2}$ mile wide, 2 miles long, and 3 ft high; hummocky crests, with moderately loose surfaces stabilized by vegetation	Ked clayey sands on hard-pan. 3g	Open mulga with edible shrubs and palatable perennial grasses: <i>Acacia aneura</i> (mulga)- <i>Eremophila leucophylla</i> sub-alliance (12)
	50	Slopes subject to sheet-flow: sealed, locally scalded surfaces with hard-pan exposures and minor clay pans; gradients about 1 in 500	Principally shallow red earths on hard-pan, of irregular depth near groves. 4h, minor 4j with 4j	Groves: mulga with some edible shrubs, sparse perennial grasses, forbs, and short annual grasses: <i>A. aneura</i> sub-alliance (22, 28)
3	650			Wnnderrie flats and intergroves: sparse, low mulga with stunted shrubs and annual grasses; much bare ground: dominantly <i>Acacia aneura</i> - <i>Eremophila fraseri</i> sub-alliance (6); also 22
4	600	Drainage floors: alluvial plains up to $\frac{1}{2}$ mile wide gradient, 1 in 500 to 1 in 1000; sealed surfaces with some hard-pan exposures; commonly traversed by drainage zones with multiple shallow runnels and small flood-banks		Variable mulga and other <i>Acacia</i> spp with sparse shrubs, forbs, and annual grasses: <i>A. aneura</i> 4. <i>tetragonophylla</i> (curara) (10) and 4. <i>aneura</i> 4. <i>craspedocarpa</i> (15) sub-alliances

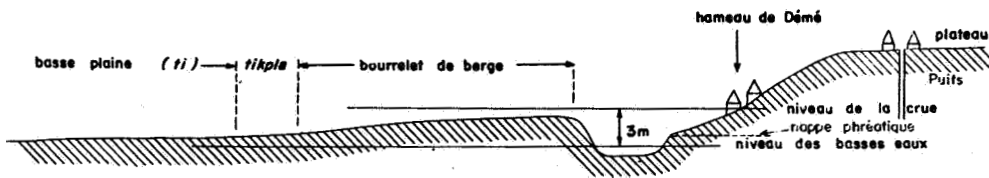
Figure 2. Airphoto taken in northern Australia, with information on land classification obtained by use of airphoto interpretation and field reconnaissance. (Commonwealth Scientific and Industrial Research Organization, Australia)



La misma porción del mosaico que oparece en la página anterior ha sido anotada con mayor detalle, señalando los factores positivos y los factores limitantes de lo capacidad de uso de la tierra agrícola.

Figure 3. Annotated airphoto mosaic showing soil and land-capability classification determined by airphoto interpretation and field check in Chile. (El Proyecto Aerofotogrametrico OEA/Chile)

Partie du terroir du village de Fanvi
(Dahomey, vallée de l'Ouémé)



Coupe Est-Ouest de la vallée de l'Ouémé.



Planche I. Epreuve-contact du cliché au 1/10 000 221/100 AOF. n° I.

Figure 4a. Contact airphoto of Lbume Valley area, Republic of Dahomey, Africa.

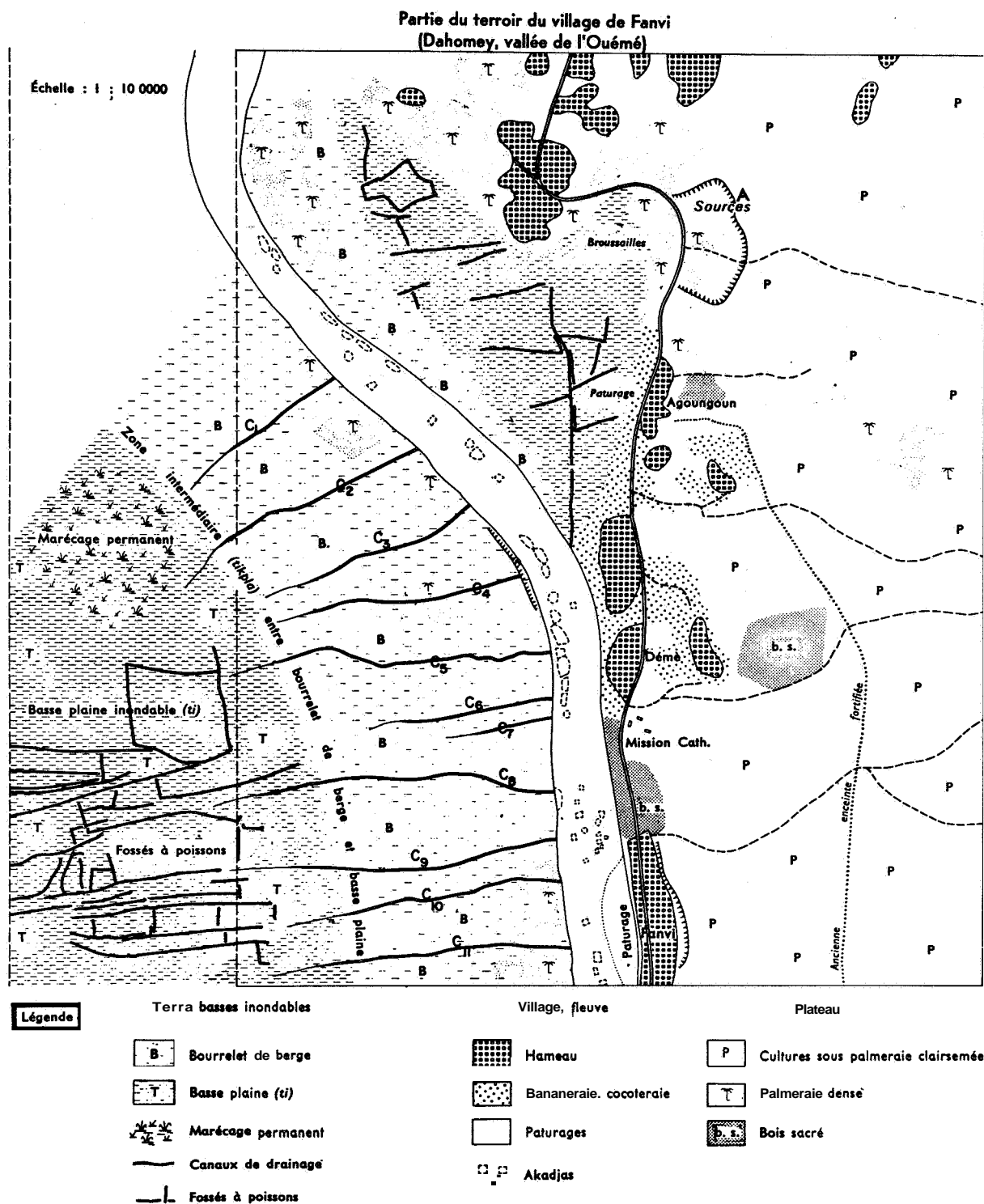
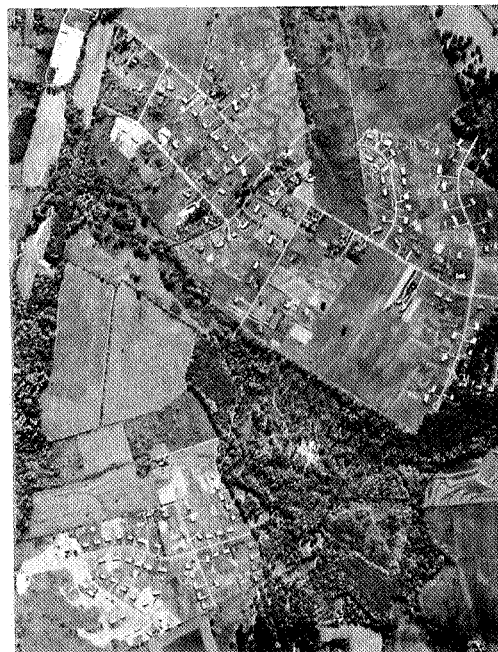
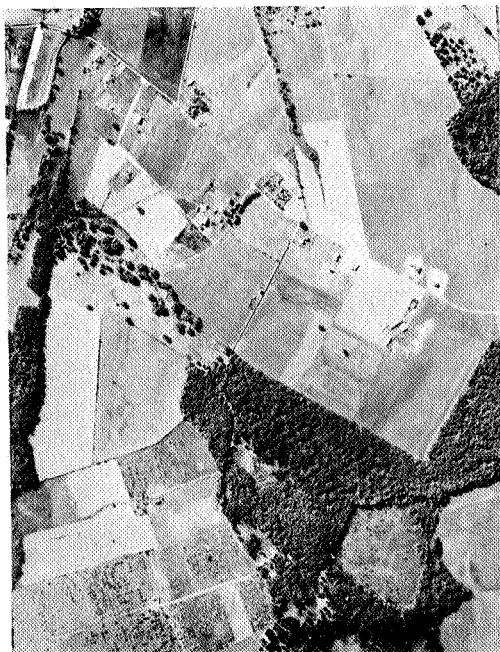


Planche II. Schéma d'interprétation obtenu par c a l m de la photographie.

Figure 4b. Land use classification and cultural data for use in area planning, obtained by stereo interpretation of airphoto shown in Figure 4a. (Institut Géographique National, France)



New farmland being developed by clearing and draining forest land in Madison Parish, La. Airphoto on left was taken in 1956; that on right in 1964. The smoke in the 1964 picture is from burning windrows of trees.



Farmland shifting to residential use in Montgomery County, Md Airphoto on left was taken in 1951; that on right in 1963.

Figure 5--The above pairs of airphotos illustrate the changes taking place in agricultural use of land in the United States.
(Economic Research Service, U. S. Department of Agriculture)

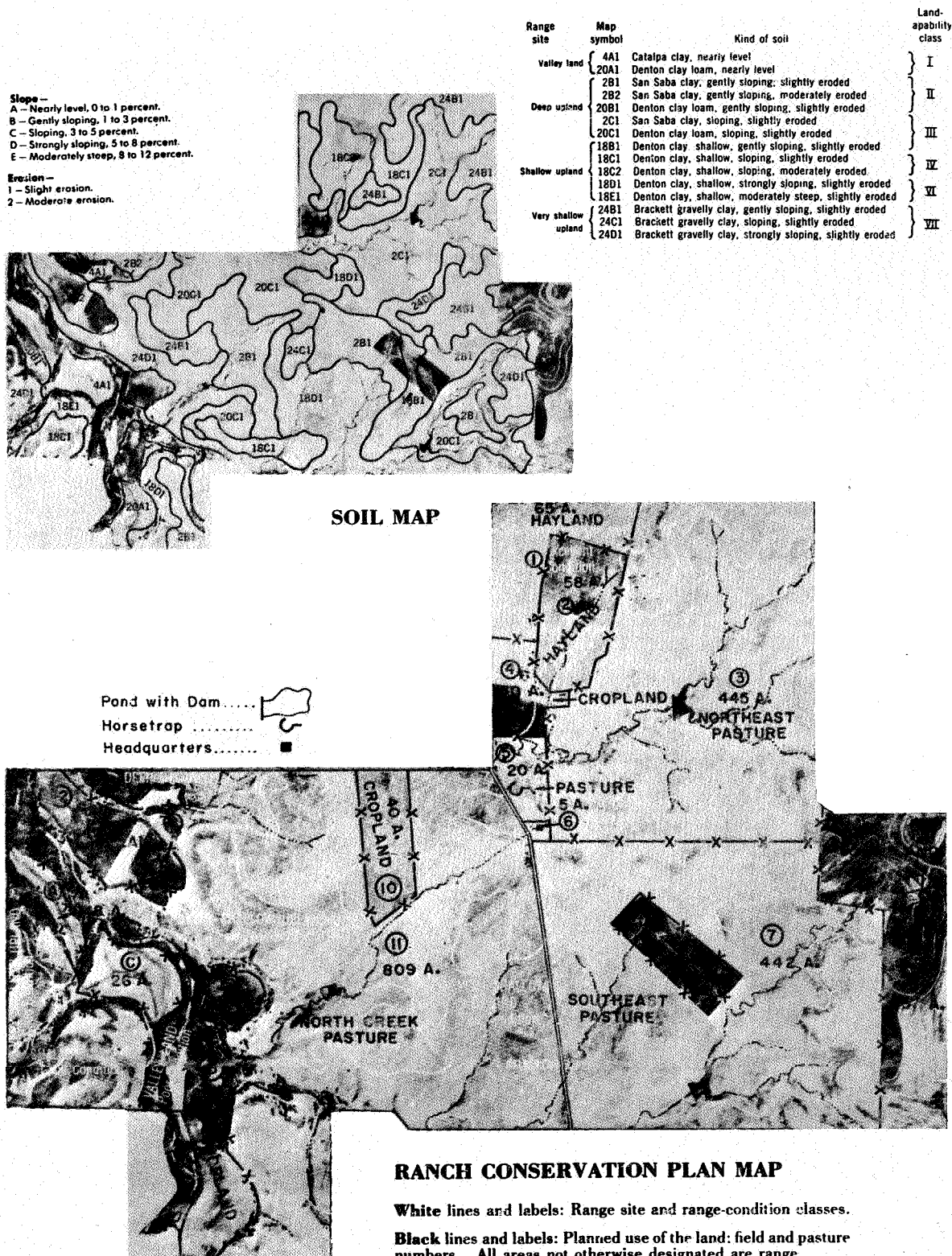


Figure 6. Use of airphotos in planning and implementing soil conservation program on rangeland in the United States. (Soil Conservation Service, U.S. Department of Agriculture)

To illustrate the use of airphotos in agriculture or in agricultural development throughout the world, a sample of 32 countries and the United States was selected for study. Information on the use of airphotos and amount of airphoto coverage in each of the countries was obtained from all available sources.

AIRPHOTO COVERAGE--WORLD SAMPLE

Nearly all countries in the world have some airphoto coverage, particularly in the developed portions of countries. Typically, the coverage is discontinuous and there is variation in the scale. In many countries the scale of photography is small since the airphotos are obtained primarily for the preparation of maps. In a few countries, airphoto coverage is restricted to military use and is not available to civilian agencies (19). For the most part, coverage is black and white vertical, although several countries have trimetrogon coverage (combined vertical and oblique shots) taken before, during, and after World War II by the U. S. Air Force. Several countries have infrared photographs of special areas, usually for forest surveys, and in a few countries experimental work has been carried out using color film and camouflage detection film (Ektachrome infrared).

For use in agriculture and related studies, photographic coverage can be classified in three categories: small, medium, and large scale.

Small-scale photographs (1:30,000-1:60,000) provide for general topographic mapping and geomorphological studies, and aid in making general surveys of soil, geology, and land use.

Medium-scale photographs (1:10,000-1:30,000) are valuable to agricultural studies since they provide sufficient detail for obtaining data on land use and capability, detailed soil surveys, vegetation mapping, and other items.

Large-scale photographs (greater than 1:10,000) are used for detailed studies of crops, for preparation of engineering plans, and for hydrologic evaluations.

Table 1 shows the airphoto coverage of existing and potential agricultural areas for the sample of countries studied. Many countries have only recently acquired airphoto coverage suitable for use in connection with agriculture.

Methods of procuring photographs vary in the sample countries. In the past, and in some of the countries at present, airphoto coverage was taken by the military or other government agency primarily to obtain small-scale mapping photography. The more recent trend has been to procure airphotos by contracting with private organizations, a coverage generally obtained on a project basis for carrying out inventory and planning for development of natural resources. Several of the countries studied have a coordinating organization to review needs for airphotos and to promote multipurpose use of airphoto coverage by all Government agencies.

Table 1--Airphoto coverage of existing and potential agricultural and range areas

Country	Percentage of coverage			Approximate dates of coverage	Remarks
	Small scale	Medium scale	Large scale		
Australia	100	Partial	Partial	Largely before 1950	
Brazil	100	Partial	Partial	1942-62	
Canada	100	100	Partial	1940-66	
Chile	100	Partial	Partial	1945-63	
Costa Rica	100	-	-	1947	
Denmark	-	100	-	1956	
East Germany	-	Partial	-	Post WWII Period	
Ecuador	Partial	Partial	-	1940-63	1:60,000 coverage being flown
El Salvador	100	Partial	Partial	1949-63	
Guatemala	100	Partial	-	1952-64	
Honduras	85	Partial	Partial	1954-63	
India	Partial	Partial	Partial	1939-65	
Kenya	Partial	Partial	-	1963	U. N. Special Fund Project
Mexico	100	Partial	Partial	1940-57	
Morocco	100	-	-	Post WWII Period	
Netherlands	-	100	Partial	1934-50	
New Zealand	100	Partial	Partial	Largely before 1950	
Nicaragua	Partial	Partial	Partial	1946-64	
Nigeria	Partial	Partial	-	1962	U. N. Special Fund Project
Paraguay	100	-	Partial	1940-64	
Peru	Partial	Partial	Partial	1941-63	
Rumania	-	Partial	-	Post WWII Period	
South Africa	90	Partial	Partial	1940-59	
Spain	-	Partial	-	Largely after 1941	
Sudan	100	Partial	-	1942-62	
Thailand	Partial	Partial	-	1956-57	
Togo	-	100	-	1962	
Turkey	-	Partial	-	1964	
U.A.R. (Egypt)	100	100	Partial	1953	Recent coverage for U. N. Special Fund Project
United Kingdom	Partial	100	Partial	1945-56	U. N. Special Fund Project
United States	Partial	95	Partial	1936-65	U. N. Special Fund Project
Venezuela	Partial	Partial	Partial	1936-64	
Yugoslavia	-	Partial	Partial	1949-55	

USE OF AIRPHOTOS--WORLD SAMPLE

The main areas of application and subject matter fields for airphoto use are presented in table 2. Since this use varies widely and in intensity, a summary of use is presented for each country studied.

Australia--In Australia, use of airphotos in relation to inventory and development of agricultural resources started just after World War II and has continued to the present. Airphoto interpretation and field reconnaissance have been used to determine agricultural potential and types of land suitable for development by classification into "land systems," particularly in the relatively undeveloped area of northern Australia. The methodology was developed shortly after World War II by the Commonwealth Scientific and Industrial Research Organization (1). Fourteen areas, accounting for more than 600,000 square miles have been surveyed in Australia and New Guinea (2).

Brazil--Use of airphotos in agriculture or in agricultural development has generally been limited to special projects, although large-scale soil maps on an airphoto base have been made for a small portion of Brazil. A project in the State of Sao Paulo being carried out by the Instituto Agronomico of that State is making use of airphoto interpretation to produce six 1:25,000 map series of the entire State. The six topics cover detailed soil survey, vegetation, inventory of plants for food and industry, cadastral survey, watershed management survey, and land capability and planning survey. In addition, airphotos are being used in a study of the Sao Francisco River Valley in carrying out a soil survey preliminary to irrigation development, and in a study of the hydrologic resources of the Jaguaribe River Basin (13). Airphotos have already been used to prepare soil maps of a portion of the Amazon Basin in conjunction with a forest inventory project using World War II trimetrogon photography at a scale of 1:40,000.

Canada--Canada's use of airphotos has included all of the major applications in many of the subject matter areas, including land use and land-use changes, soil and land capability, and soil conservation; and in the development of water supply, drainage, flood control, and pasture development projects (8). There is complete airphoto coverage for the agricultural areas, with more than one coverage in many areas (26). Airphoto interpretation is used by the Canada Department of Agriculture, as well as by the provincial government agencies, in carrying out agricultural studies. Use of airphotos in Canada is greatly facilitated by a unique institution, the National Air Photo Library, maintained by the Department of Mines and Technical Surveys in Ottawa. This institution maintains complete records of all photographs taken by and for the Federal Government and contains approximately 3 million oblique, vertical, and trimetrogon photographs. The Library provides the means for making many types of rapid studies for use in planning programs for agricultural economics, rehabilitation, and development throughout Canada (7).

Chile--Most airphoto use in agriculture has been in connection with mapping soil, land use, and land-use capability under the Proyecto Aerofotogrametrico OEA-Chile, completed in 1963, in the principal agricultural regions. Airphoto interpretation and fieldwork are providing the information to be shown on overlays on the 1:20,000 photo mosaic available for most of the agricultural areas.

Table 2--Major uses of airphotos in agriculture, by subject matter 1/ and by country, world sample

Country	Major application															
	Survey base								Airphoto interpretation							
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Australia.....	X	X	X	-	X	X	-	-	-	-	-	X	-	-	-	-
Brazil.....	X	X	X	X	X	-	-	-	-	-	-	X	-	-	-	-
Canada.....	X	X	X	X	X	X	-	-	-	-	-	-	-	-	-	X
Chile.....	X	X	X	X	-	-	-	-	X	-	-	-	X	-	-	-
Costa Rica.....	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-
Denmark.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
East Germany.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Ecuador.....	X	X	X	-	X	-	-	-	-	-	-	-	X	-	-	-
El Salvador.....	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Guatemala.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Honduras.....	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
India.....	X	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-
Kenya.....	X	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-
Mexico.....	X	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-
Morocco.....	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Netherlands.....	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-
New Zealand.....	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
Nicaragua.....	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Nigeria.....	X	X	X	-	-	-	-	-	X	-	-	-	-	-	-	-
Paraguay.....	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Peru.....	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Rumania.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
South Africa.....	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Spain.....	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sudan.....	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Thailand.....	X	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-
Togo.....	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Turkey.....	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
U.A.R. (Egypt).....	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
United Kingdom.....	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-
United States.....	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Venezuela.....	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Yugoslavia.....	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-

1/ Letters in boxheads stand for subject matter as follows:

- | | | |
|-------------------------------|--------------------------------------|--------------------------------------|
| A. Soil classification | J. Crop disease detection | S. Soil drainage program |
| B. Land use capability | K. Flood control survey | T. Agricultural colonization program |
| C. Land use classification | L. Water development | U. Agrarian reform program |
| D. Land use change studies | M. Watershed and hydrologic studies | V. Crop acreage control program |
| E. Natural vegetation | N. Recreation site evaluation | W. Reclamation programs |
| F. Livestock and range survey | O. Wildlife habitat studies | |
| G. Soil erosion survey | P. Wildlife inventory and management | |
| H. Crop identification | Q. Soil conservation program | |
| I. Crop estimates | R. Irrigation program | |

Special area studies are being carried out using airphotos to map soils, geomorphology, and water resources, although much of this work is unpublished (13). The Ministerio de Agricultura has made some use of airphotos in soil surveys, and their technicians received experience in conjunction with the use of airphotos in the OEA-Chile project.

Costa Rica--Although Costa Rica has airphoto coverage for nearly all the country, very little use has been made of airphotos in connection with agriculture. Most of the coverages are small-scale photographs taken by the U. S. Air Force. At the present time, only three coastal areas have 1:20,000 coverage, but a program is underway to photograph large portions of the central part of the country at this scale (13). The Instituto de Tierras y Colonizacion has been using airphoto interpretation in planning agricultural colonization projects since about 1963. The airphoto comparison technique was employed in a study of land-use changes.

Denmark--While Denmark has airphoto coverage for the entire country, no use is made of airphotos in connection with agriculture. Use is confined to map compilation and checking changes in the coastline.

German Democratic Republic (East Germany)--Although the German Democratic Republic is presently capable of using airphotos in agriculture, only limited use has been made. Airphotos are utilized, however, in management of the State forests (15).

Ecuador--Agricultural use of airphotos in Ecuador began in 1961, when one of the few relatively detailed land-use maps in Latin America was prepared for one basin by Professor Nilo Bernardes for the Pan American Institute of Geography and History. The map, entitled the "Utilizacion de Suelo en la Hoya del Guailabamba" (Land Use in the Guailabamba Basin), at a scale of 1:100,000 was based on airphoto interpretation and field observations, and shows agricultural land-use groupings, uncultivated lands, and urbanized areas (13). Airphotos were also used in an inventory and evaluation study (11) of the Guayas River Basin by the Organization of American States (OAS), to provide a point of departure for planning and programming regional development. Airphoto interpretation was used during a 2-month reconnaissance of the basin to provide data on soils, land use, forests, and water resources (11). A major \$1.1 million project financed by the Inter-American Development Bank is about to get underway in the Guayas Basin based on the OAS preliminary study. This project will provide basic data for investigating the feasibility of specific resource development projects and will make extensive use of airphoto interpretation.

El Salvador--Although El Salvador has small-scale photography for the entire country and medium-scale coverage for 75 percent, only limited use has been made of these airphotos in agriculture or in agricultural development. The main use has been in connection with the 1:50,000 soil-mapping program, which is now about 60 percent completed for the country (13).

Guatemala--Guatemala has complete airphoto coverage at a scale of 1:60,000 and more than 75 percent of the country has coverage at a scale of 1:40,000. Most of the 1:60,000 scale is more than 10 years old but the 1:40,000 was made during 1961-64 (13). Some medium-scale photography has been taken since 1961.

The most recent medium-scale photography, taken in 1964 and 1965, is to be used for a land-capability survey as well as for topographic and cadastral mapping. In 1961, the Direccion General de Cartografia (now the Instituto Geografico Nacional) compiled a vegetation and land-use map for the Sebol region of Guatemala by means of airphoto interpretation.

Honduras--Two recent programs have provided a large amount of airphoto coverage in Honduras. The U. S. Air Force photographed about 85 percent of the country at a scale of 1:60,000 between 1954 and 1961 in connection with the topographic program of the Direccion General de Cartografia (13). The second program for airphoto coverage was for a pine forest inventory project undertaken jointly in 1963 by the Ministerio de Recursos Naturales and the U. N. Special Fund. This photography at a scale of 1:20,000 covered several large areas and additional areas located along the coast and in the southeastern section of the country. It is anticipated that this coverage will be used for planning and development in agriculture. An additional study using airphoto interpretation was made by the OAS, showing slope for about 80 percent of the country and soils in several selected areas (12).

India--Airphoto coverage in India is not complete and is on scales varying from 1:10,000 to 1:30,000. Airphotos are used primarily for preparation of maps. A start has been made in the use of photographs for the assessment and development of natural resources--land, mineral, and forest. Various governmental departments request photographic services from the Survey of India where coordination of scales is achieved and photographic specifications are established. Air photography is performed by the Indian Air Force and Air Survey Company Private Ltd. A proposal for the expansion of photographic capacity is under consideration by the Planning Commission to meet the increasing need for mapping and photographic interpretation.

Use of airphoto interpretation is just getting underway in India, prompted by courses on airphoto interpretation which Survey of India personnel attended at the International Training Center for Aerial Survey, Delft, the Netherlands. These personnel are now available to train other people in interpretation techniques. Training in the use of airphotos for soil survey was started in 1962 by the Indian Agricultural Research Institute. Interpretation of enlargements of 1:25,000 scale airphotos was used to locate severely eroded areas by the Interstate Soil Conservation Board in a soil conservation survey of Punjab and Himachal Pradesh.

Since 1962, airphotos have been used for land-use capability classification, geomorphology, soil survey, groundwater, wasteland, and vegetation surveys by the Central Arid Zone Research Institute, Jodhpur. Airphoto interpretation techniques are being used for watershed management by the Damodar Valley Corporation in Bihar and West Bengal. Use of airphoto interpretation in agriculture in India will likely increase considerably in the future.

Kenya--Agricultural use of airphotos in Kenya in the early fifties was described by F. Walker (25). Airphoto interpretation was used to make a land classification overlay on an airphoto mosaic of a proposed sisal plantation on the coast of Kenya. The classification units included rocky areas, eight natural vegetation units, shifting African cultivation, and lands in process of regeneration.

The most recent use of airphotos in Kenya is for a survey of the irrigation potential of the Lower Tana River Basin under the Cooperation Program of the U. N. Special Fund (22). New large-scale airphotos have been acquired and semidetailed soil and plant classification maps will be made by use of airphoto interpretation and field checking. To date, maps have been completed for 700,000 acres. Plans for the Yala Swamp development will be based on airphotos. Semidetailed soil and vegetation maps will be made while dredging equipment is being obtained.

Mexico--Use of airphotos in connection with agriculture includes application in three subject-matter fields: soil, land utilization, and vegetation mapping (13). Since 1960, all of the soil survey work of the Secretaria de Recursos Hidraulicos (SRH) has been carried out by using airphotos as the mapping base. The major source of land-use maps has been the SRH, where they have been prepared as part of regional agricultural development studies. In recent years, airphoto interpretation has been used in the compilation of these maps. During 1963 and 1964, the Direccion General de Geografia y Meteorologia (DGGM) compiled an agricultural zone map of the entire country at a scale of 1:50,000 showing seven categories of agricultural land and natural vegetation.

Morocco--The major use of airphotos in agriculture in Morocco is in connection with soil surveys. The airphoto coverage available for the agricultural area has a scale of 1:50,000 and was flown under the previous French administration. The type of survey being carried out is similar to that used by the Soil Conservation Service, **USDA**. Several of the soil scientists have been trained in the United States. Officials in Morocco recognize a need for larger scale photography to provide a type of survey similar to the U. S. county soil survey.

The Netherlands--Airphotos have been used in the Netherlands for many phases of agriculture and forestry. Photography at 1:10,000 and 1:20,000 is available and has been used in preparation of soil maps, in drainage studies, in study of wasteland, crop disease detection, and in connection with new land projects (16). Great emphasis has been placed on use of airphotos for both mapping and interpretation in the Netherlands. A state-supported institute, the International Training Center for Aerial Survey at Delft, is well known throughout the world for its training program, consulting services, and project work. Many scientists in the less developed countries have received training at the Center and this program is still continuing.

New Zealand--Use of airphotos in agriculture in New Zealand has been somewhat limited, although they are used extensively in forest surveys. Some use has been made in connection with engineering and land development and in conservation and catchment programs. All the North Island and about two-thirds of the South Island have been photographed. The Department of Aerial Survey and Topographic Mapping is responsible for maintaining a complete library of airphotos which are made available for all national purposes.

Nicaragua--Airphotos are being used in several phases of agriculture in Nicaragua (13). The Departamento de Suelo is carrying out soil and land-capability studies using medium- and large-scale airphotos. This systematic soil survey was initiated in 1962 with the assistance of a technician from the Food and Agriculture Organization (FAO) of the United Nations. The first sheet

of this photomap series was published at a scale of 1:50,000 in 1963. Airphotos at a scale of 1:15,000 are being used in a preinvestment survey started in 1963, sponsored by the U. N. Special Fund in cooperation with the Instituto de Fomento Nacional. Land capability for agriculture and cattle raising is being studied. A land-use map is being prepared, based on airphoto interpretation and field investigation. The area under study includes about 10,000 square kilometers between the Huahua and Prinzapulca Rivers.

Nigeria--Until recently, use of airphotos in Nigeria was mostly confined to forestry except for a study of cacao farms to obtain information on the distribution of farms, and for spotting insect damage (10). In 1962, a soil and water resource survey, in cooperation with the U. N. Special Fund Program, was started in the Sokoto River Valley, using airphotos at a scale of 1:40,000 with 1:20,000 enlargements of special areas. The work to be carried out includes a reconnaissance soil survey of the watershed, semidetained soil surveys of the flood plain of the river and lower reaches of the main tributaries, and land-use erosion studies of the watershed for improved management of present cropland.

Paraguay--Airphotos were not used in connection with agriculture in Paraguay until recently. The only photographic coverage available for most of the country was trimetrogon photography taken by the U. S. Air Force from 1943 to 1945, which covered all but the northeast corner (13). A new project, the "Plan Triangulo," is now underway which will cover most of eastern Paraguay. New airphotos at a scale of 1:50,000 will be used in planning development, agricultural colonization, and road construction. This project, in cooperation with the U. N. Special Fund, is one of the few integrated investigations of natural resources through airphotos presently in operation in Latin America.

Peru--Agricultural use of airphotos in Peru has been limited, but there is great interest in studies of natural resources and in regional and agricultural planning. A photogrammetry project is under consideration that would include the necessary photographic coverage on scales of 1:20,000, 1:50,000, and 1:100,000 to evaluate Peru's natural resources and assemble the basic information needed to plan the country's economic development. Several semidetained soil studies completed between 1958 and 1961 on small but important agricultural areas were made by using airphoto interpretation (13).

Rumania--Limited use of airphotos in connection with agriculture has been made in planning and implementing land reclamation and soil conservation projects in Rumania. Airphotos have also been used in forest and land-use surveys.

South Africa--Several applications of airphotos have been made in connection with agriculture in South Africa. Airphotos are being used by the Soil Institute of the Department of Agriculture to prepare soil maps, and by the National Institute for Roads Research to produce soil engineering maps by defining areas covered by various soil types. In addition, airphotos are being used in antierosion farm planning, land utilization, forest surveys, and land valuation. For much of this work, the scale of the photographs obtained for map compilation was too small and special coverage at scales of 1:15,000 to 1:25,000 was obtained for some areas (4).

Airphotos have been used in planning settlement of areas where no maps were available. Airphotos used to determine topographic data, land use, existing

roads, and culture, greatly reduced the field work. Stereo interpretation provided data on watershed boundaries and catchment areas. Grazing areas have been marked out by stereoscopic study of airphotos for classifying areas according to different veld and soil types. Veld types have been classified, mapped, and described, and on the basis of further detailed field inspection, grazing systems have been compiled in the form of a grazing management manual for use by all field officers in the less developed areas (14).

Spain--Agricultural use of airphotos in Spain has been somewhat limited, although, where available, they have been used as an auxiliary source of information in preparing a land-use map of the country by the Ministerio de Agricultura. They were also used in agricultural development programs in the semi-arid portion of the country (3).

Sudan--Sudan's agricultural use of airphotos is relatively recent, although they have been used in forest studies for some time (10). Under the U. N. Special Fund Program, airphotos are being used in two projects. One project is designed to assist the new Soil Survey Division in soil survey and land classification by making reconnaissance surveys to determine which areas are suitable for irrigation and other types of development. The project is designed both to complete the survey and to train Sudanese personnel in photo interpretation and field mapping. The second project is a survey of land and water resources in the Jebel-Marra area (about 37,000 square miles). Airphotos will be used for detailed investigation of prevailing soil and land-use conditions there, including measurement of grassland, forest, and cropland areas, and identification of cropping practices. The Sudanese Government will photograph the area at a scale of 1:40,000, and where needed, at 1:20,000.

Thailand—Thailand's use of airphotos in agriculture is fairly recent although they were used in a national forest inventory in 1956-57 (18). Airphotos, currently being used for forest and soil surveys at 1:40,000, are being taken primarily for map compilation. Need for large-scale airphotos (1:15,000-20,000) is recognized for both agricultural and forest surveys. Up-to-date coverage is needed because about 30 percent of the forest land has been cleared and put into cultivation since the airphoto coverage of the early fifties (21).

Togo--A soil and water resource survey of Togo is making use of airphotos augmented by field work to prepare a soil map at a scale of 1:50,000, based on a photomosaic at a scale of 1:20,000. Detailed reconnaissance studies on airphotos at 1:20,000 have been completed for 160,000 hectares in the northern section. A soil map showing 55 soil series for the southern section has been completed on the 1:50,000 scale. The survey is being carried out under the U. N. Technical Cooperation Program of the U. N. Special Fund.

Turkey--Airphoto interpretation is being used in a preinvestment survey of the Anatolia Region. A land-use map of the region is being compiled on the basis of airphotos at a scale of 1:25,000, and so far about 700,000 hectares have been completed. This pilot regional development program, whose aim is to train Turkish personnel in area development planning, is being carried out under the Technical Cooperation Program of the U. N. Special Fund.

United Arab Republic (Egypt)--The major agricultural use of airphotos is for soil survey and land classification to provide information necessary for

improvement programs in presently cultivated areas and for development of reclamation projects. Soil survey work was begun in 1955, and three types of surveys are being conducted: reconnaissance, scale 1:100,000; semidetalled, 1:25,000; and detailed in specific areas, 1:2,500 (6). A soil survey is being made on the desert fringes of the cultivated portion of the Nile Valley using airphotos at 1:40,000 and 1:20,000 scales taken in 1953. The survey is being done by airphoto interpretation and field checking by a Netherlands team working with the Soil Survey Section of the Soil Administration of the UAR under a U. N. Special Fund project. An area of about 2 million acres is to be surveyed and soil scientists will be trained in the process (22).

United Kingdom--Use of airphotos in agriculture has been primarily in soil surveys in England and Wales (9). However, agricultural use in the Commonwealth countries and in the colonies has been promoted by scientists in the United Kingdom. The Directorate of Overseas Surveys has carried out many inventory and planning projects using airphotos to obtain basic data. Several private organizations have carried out predevelopment surveys using airphotos (25). In several former British colonies, use of airphotos which began under the colonial administration is continuing under the new governments for inventory and planning of areas for agricultural development (28).

United States--In the United States, agricultural use of airphotos started in 1934 and has included all the main areas of application--as a base for surveys, to obtain information by airphoto interpretation, and as base for program planning and administration. The U. S. Department of Agriculture has the most complete medium-scale airphoto coverage for the country, practically all of which was obtained for use by the Agricultural Stabilization and Conservation Service and Soil Conservation Service. For the most part, this coverage is at 1:20,000 contact scale, is usually flown on a county basis, and is fairly recent for most areas. Many counties have two or more flights which provide the opportunity to make comparisons and measure changes in land use and other features. For most of the major agricultural areas, new coverage is obtained every 6 years. In addition to use by the procuring agency, other agencies, including the Economic Research Service, Statistical Reporting Service, and many State and local agencies use the photographs to carry out studies in the subject matter fields shown in table 2.

Venezuela--Venezuela's history of aerial photographic coverage began in 1936. Seventy-five percent of the country has been photographed at least once, including all the developed northern portion (13). Most of the soil and vegetation studies have involved the use of airphotos.

Yugoslavia--Use of airphotos is fairly recent in Yugoslavia. They have been used in making forest maps and in identifying forest types and arable land in the Karst Region. The airphotos used were at scales of 1:10,000-1:15,000 where available; otherwise, 1:20,000 scale photographs were used (20). Increasing use of airphotos is anticipated, since courses in photogrammetry are now being given by the Geodetic Department of the University of Zagreb for students in the Department of Forestry and Agriculture.

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